

November 1993 Preliminary Data Summary

by Field Research Facility

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Preface

This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

1 Introduction

The U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's (CERC) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.75 m above the National Geodetic Vertical Datum (NGVD) of the year 1929.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919) 261-3511.

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Figure 2 shows weather and ocean conditions for the month. Table 2 and Figure 3 identifies the location of the instruments. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 9. Other installation information is contained in Table 1.

Times given in the report are referenced to eastern standard time (EST).

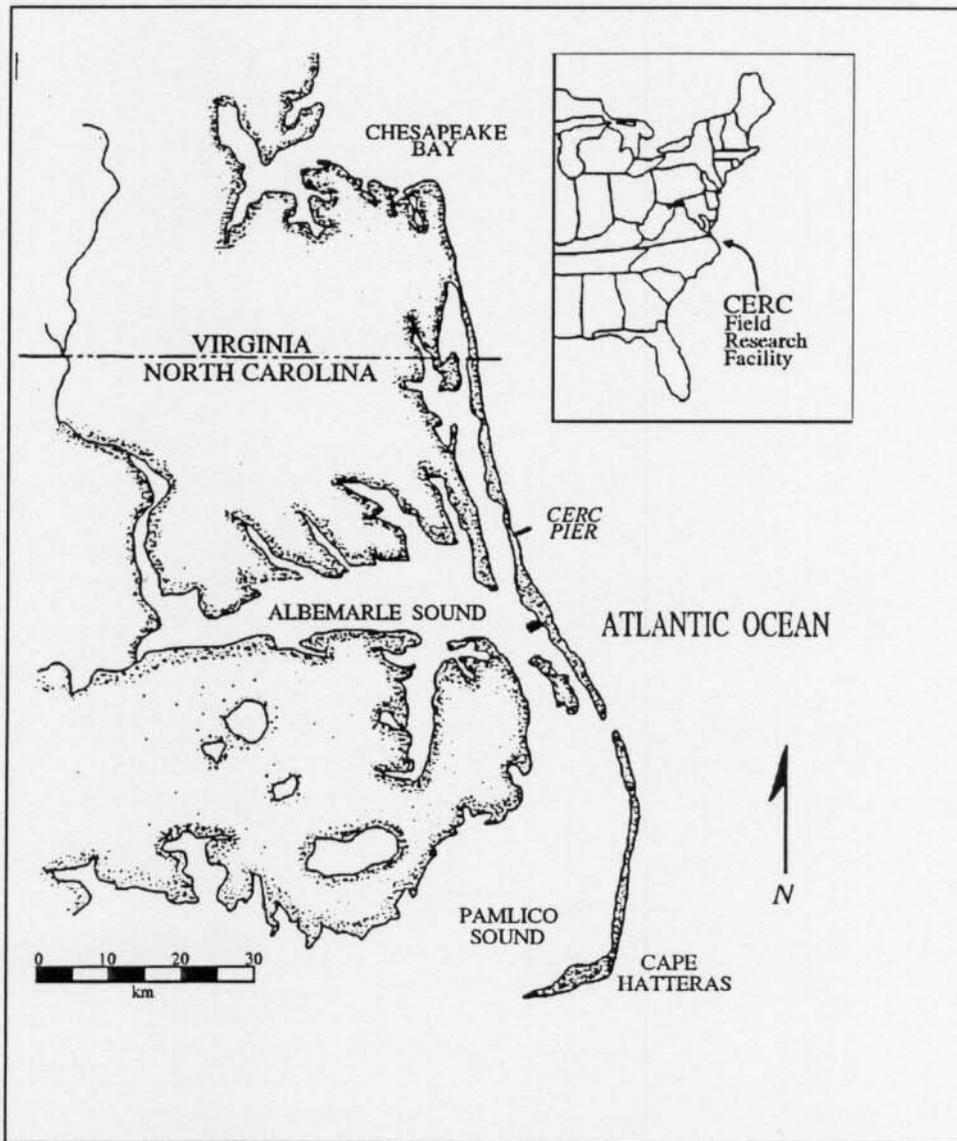


Figure 1. FRF Location Map

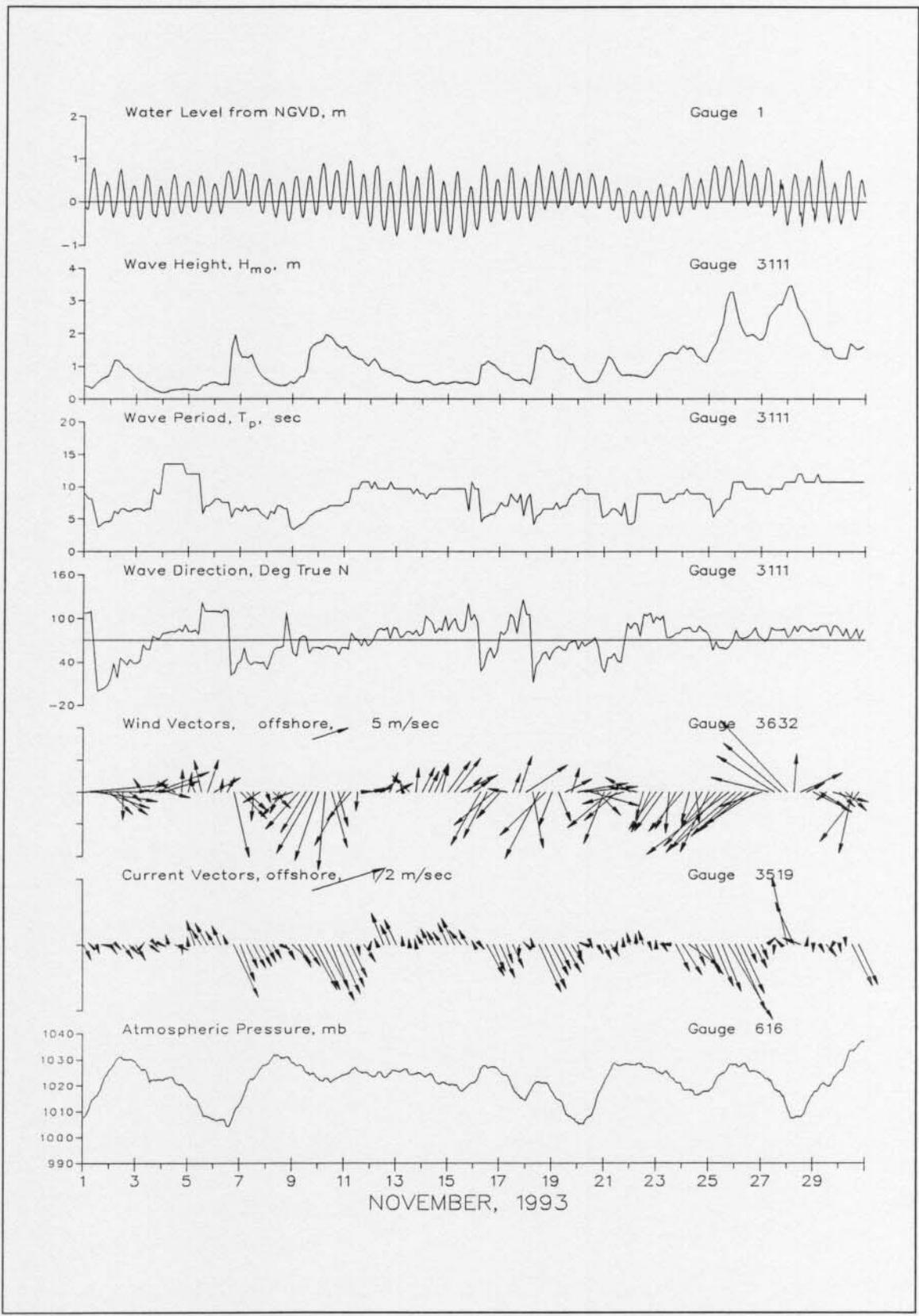


Figure 2. Month at a Glance

**Table 1
Instrument Status/Data Availability**

			November 1993																														
			Day of the month																														
Gauge ID	Description/Remarks																																
			1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	
616	Atmospheric Pressure	Gauge Status	*																														
		Data Collected	*																														
604	Precipitation	Gauge Status	*																														
		Data Collected	*																														
624	Air Temperature	Gauge Status	*																														
		Data Collected	*																														
632	Anemometer on top of building	Gauge Status	*																														
		Data Collected	*																														
932	Anemometer at seaward end of pier	Gauge Status	*																														
		Data Collected	*																														
641	Pressure Gauge at station 780 on FRF pier	Gauge Status	*																														
		Data Collected	*																														
625	Baylor staff at station 1860 on FRF pier	Gauge Status	*																														
		Data Collected	*																														
3111	8 Meter Array 309 m north of FRF	Gauge Status	*																														
		Data Collected	*																														
511	Pressure Gauge 434 m north of FRF pier (0.9 km offshore)	Gauge Status	*																														
		Data Collected	*																														
630	Waverider buoy 4.0 km offshore	Gauge Status	*																														
		Data Collected	*																														
519	Current meter 434 m north of FRF pier (0.9 km offshore)	Gauge Status	*																														
		Data Collected	*																														
1	NOAA tide station at seaward end of FRF pier	Gauge Status	*																														
		Data Collected	/ * * * * * / * * * * *																														
	Visual Observations (daily oceanographic and meteorological observations)	Daily observation	*																														

Gauge Status * = Operational / = Partial - = Non-Operational
 Data Collected * = All / = Partial - = None
 Visual Observations * = Complete / = Partial - = None

Table 2
Gauge Locations

Gauge ID	Description	Latitude Degrees N	Longitude Degrees W	FRF Coordinates		Gauge Depth NGVD, m	Water Depth NGVD, m
				X, m	Y, m		
616	Barometer	36 10' 45.48"	75 44' 37.39"	11.60	569.00	-----	-----
632	Building Anemometer	36 10' 45.24"	75 44' 39.53"	21.45	515.83	19.94	-----
932	EOP Anemometer	36 11' 2.64"	75 44' 46.50"	585.20	517.30	19.50	-----
641	780 Pressure	36 10' 51.96"	75 44' 42.21"	239.11	516.64	-1.64	-1.96
625	1860 Baylor	36 11' 2.10"	75 44' 46.31"	568.00	516.64	Surface	-8.36
3111	8m Array	36 11' 15.90"	75 44' 38.88"	914.43	825.52	-7.76	-8.08
511	Pressure N Tripod	36 11' 17.17"	75 44' 34.15"	914.76	950.00	-6.70	-7.90
630	Waverider	36 12' 16.44"	75 47' 19.23"	3934.96	-2400.81	Surface	-17.00
519	Current N tripod	36 11' 17.17"	75 44' 34.15"	914.76	950.00	-5.30	-7.90
1	NOAA Tide	36 11' 2.95"	75 44' 46.76	596.49	514.20	Surface	-7.62

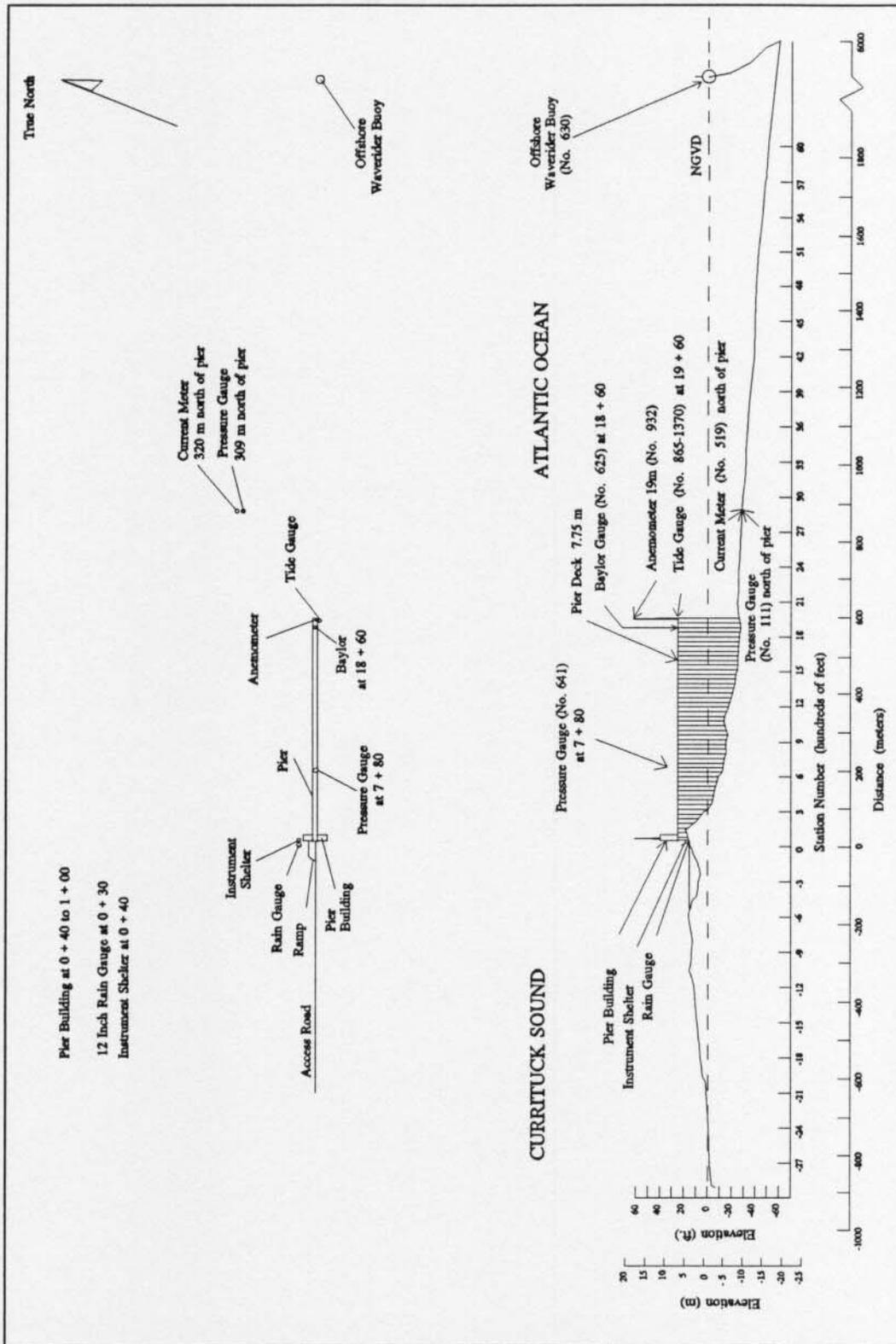


Figure 3. Instrument Locations, Elevations From NGVD

2 Meteorological Data

A variety of instruments have been installed at the FRF (Figure 3) to monitor the meteorological conditions. The data presented in Table 3 are collected and stored using a Digital Equipment Corporation VAX 11/750. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m (Figure 4) using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions are determined by vector averaging the data. Wind directions indicate where the wind is coming from. Temperature and atmospheric pressure means are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 3 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -
 $\text{mm} \times .03937 = \text{in.}$
2. Millibars (mb) to inches of mercury (in. Hg) -
 $\text{mb} \times 0.02953 = \text{in. Hg}$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -
 $(\text{C} \times 9/5) + 32 = \text{F}$
4. Meters per second (m/s) to knots (kn) -
 $\text{m/s} \times 1.943 = \text{kn}$

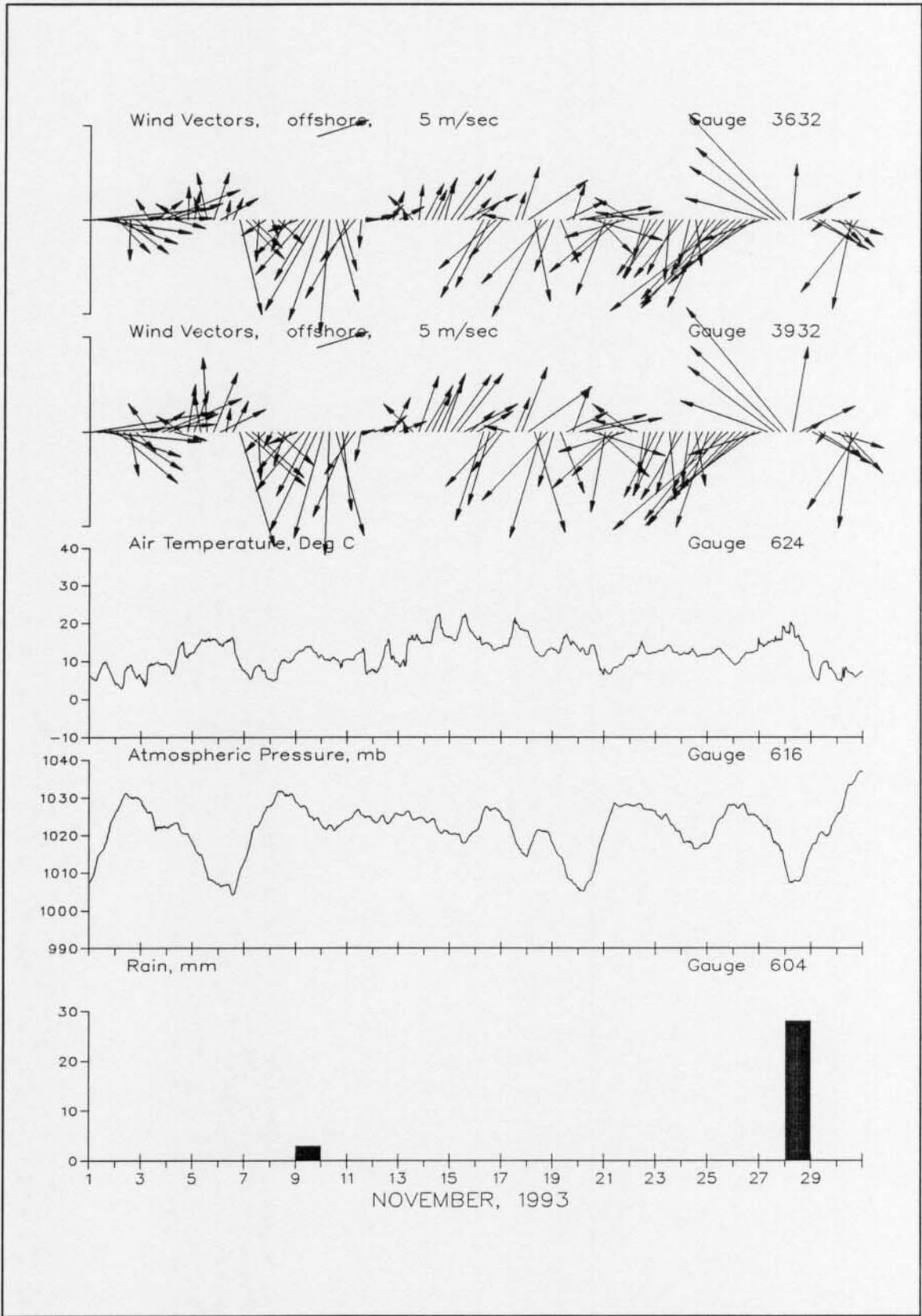


Figure 4. Meteorological Monthly Summary

Table 3
Meteorological Data

November 1993						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	11	259	6.2	1007.7	0
	700	11	265	5.4	1012.7	0
	1300	9	277	9.5	1016.2	0
	1900	7	292	7.5	1021.5	0
2	100	8	314	3.9	1026.2	0
	700	7	307	3.3	1029.9	0
	1300	5	350	8.7	1030.4	0
	1900	3	318	6.3	1030.1	0
3	100	2	258	5.1	1029.3	0
	700	4	148	9.0	1026.1	0
	1300	3	231	9.4	1022.7	0
	1900	8	243	9.3	1022.5	0
4	100	5	247	8.8	1022.1	0
	700	3	287	7.7	1023.1	0
	1300	3	126	14.2	1021.5	0
	1900	5	188	11.0	1020.5	0
5	100	4	196	12.3	1017.7	0
	700	4	171	14.7	1014.7	0
	1300	8	177	15.6	1010.5	0
	1900	7	199	15.8	1008.1	0
6	100	5	240	14.3	1007.0	0
	700	3	188	15.1	1006.7	0
	1300	4	203	16.4	1004.3	0
	1900	13	345	9.8	1008.9	0
7	100	8	316	7.3	1013.2	0
	700	7	315	5.7	1019.6	0
	1300	5	358	9.0	1022.6	0
	1900	3	41	7.7	1026.2	0
8	100	2	22	5.1	1027.8	0
	700	5	317	6.2	1031.3	0
	1300	4	15	10.4	1031.3	0
	1900	5	36	10.0	1031.0	0
9	100	3	64	11.9	1028.9	0
	700	8	34	12.9	1027.8	0
	1300	7	24	13.8	1025.1	0
	1900	11	21	12.4	1024.5	3
10	100	12	13	11.3	1022.6	0
	700	13	1	10.2	1022.7	0
	1300	11	346	10.4	1021.5	0
	1900	8	354	8.5	1023.1	0

Table 3
Meteorological Data (continued)

November 1993						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	10	19	10.5	1024.1	0
	700	5	31	10.8	1025.7	0
	1300	3	10	12.4	1025.8	0
	1900	1	1	6.7	1025.1	0
12	100	2	252	7.3	1023.9	0
	700	2	247	8.5	1024.4	0
	1300	2	226	14.2	1023.4	0
	1900	4	203	11.4	1024.7	0
13	100	3	1	8.6	1025.5	0
	700	1	164	8.9	1025.8	0
	1300	4	137	16.9	1024.4	0
	1900	6	197	15.8	1024.7	0
14	100	5	207	14.8	1024.1	0
	700	4	204	15.0	1024.2	0
	1300	7	202	22.1	1021.8	0
	1900	6	197	17.1	1021.3	0
15	100	7	211	16.3	1020.5	0
	700	7	214	15.9	1020.3	0
	1300	6	239	21.9	1018.0	0
	1900	3	225	18.4	1019.7	0
16	100	4	236	16.2	1021.2	0
	700	10	14	14.2	1025.7	0
	1300	8	14	14.4	1027.2	0
	1900	7	38	13.1	1027.3	0
17	100	5	33	13.6	1025.3	0
	700	2	104	14.2	1024.0	0
	1300	4	200	21.5	1019.2	0
	1900	7	198	18.5	1016.0	0
18	100	8	230	17.8	1014.7	0
	700	11	345	13.3	1019.6	0
	1300	12	14	11.3	1021.5	0
	1900	9	39	12.8	1021.1	0
19	100	6	13	13.3	1017.7	0
	700	7	341	12.4	1014.5	0
	1300	4	241	17.1	1010.3	0
	1900	5	197	15.1	1007.6	0
20	100	6	253	13.1	1005.9	0
	700	7	258	11.9	1006.1	0
	1300	7	291	14.3	1008.5	0
	1900	7	316	9.7	1015.7	0

Table 3
Meteorological Data (concluded)

November 1993						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	9	8	7.9	1021.1	0
	700	8	41	7.0	1026.0	0
	1300	6	42	8.5	1028.0	0
	1900	6	70	9.9	1028.2	0
22	100	5	129	11.6	1028.0	0
	700	4	107	11.9	1028.1	0
	1300	4	6	13.9	1027.1	0
	1900	7	12	12.0	1026.8	0
23	100	8	23	12.5	1025.8	0
	700	7	22	12.8	1024.5	0
	1300	7	356	14.0	1024.1	0
	1900	7	15	12.4	1021.5	0
24	100	8	27	11.9	1019.4	0
	700	5	6	12.0	1018.3	0
	1300	6	351	12.1	1016.4	0
	1900	7	23	11.7	1017.3	0
25	100	11	16	11.8	1017.8	0
	700	11	34	12.3	1021.6	0
	1300	12	33	12.8	1024.7	0
	1900	15	44	10.9	1027.6	0
26	100	13	38	9.2	1028.1	0
	700	10	40	10.4	1028.0	0
	1300	9	44	12.1	1026.3	0
	1900	9	48	12.5	1025.5	0
27	100	7	69	14.4	1024.2	0
	700	8	112	14.4	1022.7	0
	1300	10	131	15.4	1018.8	0
	1900	12	138	15.9	1016.9	0
28	100	16	145	17.5	1011.3	14
	700	9	188	19.3	1007.6	11
	1300	6	241	16.4	1007.9	3
	1900	2	233	12.7	1012.6	0
29	100	6	302	7.6	1016.9	0
	700	5	305	4.9	1019.7	0
	1300	2	33	9.8	1020.2	0
	1900	5	290	8.0	1022.1	0
30	100	4	322	5.2	1025.5	0
	700	6	321	5.6	1029.1	0
	1300	10	6	6.8	1033.5	0
	1900	9	28	6.3	1036.0	0
		Resultant		Mean	Mean	Total
		2	358	11.7	1021.3	31

3 Wave Data

Wave data are collected from a Baylor staff gauge (Gauge 625), two pressure wave gauges (641 and 511) and a Waverider buoy (Gauge 630) as shown in Table 1 and Figure 3. The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAX 11/750 programmed to sample the gauges for two hour and forty-eight minute time frames. The sampling rate is two times per second which equals five contiguous 34 minute records per collection period. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record.

Wave height H_{mo} is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 deg of freedom calculated from a 34-min record. Peak wave period T_p is defined as the period associated with the maximum energy in the spectrum. When this analysis is complete, the data are written to optical disc.

Table 4 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 4 are average values computed from this data. Figure 5 is a time history of all H_{mo} and T_p values obtained for all gauges.

Differences in wave periods between wave gauges (Table 4 and Figure 5) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

**Table 4
Wave Data**

November 1993									
Day	Hour	641		625		511		630	
		Pressure Hmo,m	Gauge Tp,sec	Baylor Hmo,m	1860 Tp,sec	Pressure Hmo,m	Gauge Tp,sec	Waverider Hmo,m	Tp,sec
1	0100	0.12	9.48	0.35	9.14	0.41	8.53	0.72	9.14
	0700	0.16	10.24	0.29	8.53	0.33	8.26	0.69	3.28
	1300	0.25	3.82	0.44	3.88	0.43	3.56	0.71	3.41
2	1900	0.44	4.83	0.62	4.27	0.58	4.74	0.89	4.66
	0100	0.53	4.49	0.85	4.27	0.80	4.49	1.12	4.83
	0700	0.97	5.95	1.10	6.09	1.13	5.95	1.32	6.24
3	1300	0.62	5.12	0.97	6.09	0.95	5.95	1.13	5.95
	1900	0.52	5.12	0.89	5.45	0.86	6.09	0.92	7.11
	0100	0.31	4.66	0.68	6.56	0.64	6.74	0.69	6.40
4	0700	0.24	5.02	0.47	5.82	0.48	6.40	0.55	6.09
	1300	0.13	5.02	0.38	7.11	0.38	6.74	0.39	6.09
	1900	0.10	11.13	0.23	8.53	0.26	9.14	0.35	9.14
5	0100	0.08	14.20	0.21	14.22	0.22	9.85	0.22	9.14
	0700	0.12	13.47	0.22	13.47	0.25	13.47	0.26	13.47
	1300	0.13	13.47	0.27	13.47	0.31	13.47	0.29	13.47
6	1900	0.16	12.80	0.38	12.80	0.30	12.80	0.42	12.80
	0100	0.13	12.80	0.30	12.80	0.29	12.80	0.33	12.80
	0700	0.10	11.64	0.26	12.19	0.27	12.19	0.28	12.19
7	1300	0.27	5.12	0.40	11.64	0.38	5.82	0.57	5.45
	1900	0.21	3.82	0.47	11.64	0.44	7.11	0.56	7.11
	0100	0.27	4.92	0.45	7.31	0.51	8.00	0.59	7.11
8	0700	0.18	4.66	0.40	8.00	0.42	7.76	0.50	7.31
	1300	0.22	7.11	0.39	7.53	0.41	6.92	0.55	7.53
	1900	1.07	6.92	1.96	6.40	2.02	6.74	2.19	6.92
9	0100	0.94	6.09	1.21	6.09	1.22	6.40	1.57	6.09
	0700	0.78	5.22	1.34	6.56	1.30	6.92	1.54	6.40
	1300	0.94	6.09	1.12	6.09	1.16	6.56	1.32	6.74
10	1900	0.44	4.20	0.85	5.82	0.77	6.09	0.90	6.24
	0100	0.42	4.74	0.61	5.22	0.57	5.33	0.66	5.22
	0700	0.22	4.20	0.51	5.82	0.48	5.82	0.56	5.33
11	1300	0.21	4.92	0.39	6.92	0.40	9.14	0.48	5.95
	1900	0.19	2.44	0.48	5.69	0.41	6.56	0.52	5.82
	0100	0.27	3.61	0.51	3.82	0.47	3.77	0.53	3.71
12	0700	0.37	3.66	0.81	4.00	0.65	3.61	0.77	3.94
	1300	0.45	4.20	0.74	4.66	0.73	4.27	0.90	4.49
	1900	0.90	5.69	1.52	5.95	1.57	5.69	1.86	5.95
13	0100	1.08	5.69	1.57	5.82	1.71	5.95	2.04	6.24
	0700	1.03	5.57	1.73	6.56	1.92	6.56	2.30	6.56
	1300	1.05	5.82	1.62	6.92	1.70	6.74	1.91	6.92
14	1900	0.98	6.09	1.49	7.31	1.62	7.76	1.77	6.92

Table 4
Wave Data (concluded)

November 1993									
Day	Hour	641		625		511		630	
		Pressure Gauge	Baylor 1860	Pressure Gauge	Waverider	Pressure Gauge	Waverider	Pressure Gauge	Waverider
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec
21	0100	0.75	5.22	1.00	4.27	0.94	5.02	1.08	5.45
	0700	0.66	5.69	1.34	6.40	1.26	6.40	1.46	5.82
	1300	0.70	5.57	0.94	5.82	0.86	6.24	1.11	5.69
	1900	0.43	4.83	0.78	5.69	0.68	6.09	0.85	5.69
22	0100	0.37	4.66	0.69	4.06	0.69	4.49	0.79	8.83
	0700	0.32	3.77	0.73	4.92	0.73	9.14	0.84	8.83
	1300	0.32	5.02	0.60	10.24	0.63	8.83	0.71	7.53
	1900	0.37	2.88	0.79	8.83	0.75	8.83	0.90	8.83
23	0100	0.54	9.14	1.04	9.14	0.96	8.83	1.20	8.26
	0700	0.63	9.85	1.34	8.53	1.24	9.14	1.41	6.92
	1300	0.64	9.48	1.31	7.76	1.40	7.76	1.48	7.76
	1900	0.64	9.85	1.25	8.26	1.36	9.14	1.55	8.83
24	0100	0.96	8.83	1.61	9.14	1.73	9.14	1.78	9.14
	0700	0.85	9.14	1.34	9.14	1.65	9.14	1.57	9.14
	1300	0.70	8.53	1.32	9.14	1.40	9.14	1.55	9.14
	1900	0.69	9.14	1.18	9.14	1.18	8.83	1.30	8.26
25	0100	0.80	8.26	1.30	8.53	1.30	8.53	1.33	8.26
	0700	0.98	5.69	1.59	5.45	1.69	5.57	1.83	5.57
	1300	0.97	6.92	2.00	7.53	2.21	7.11	2.41	7.31
	1900	1.18	9.14	2.81	9.85	3.27	9.48	3.61	9.14
26	0100	1.12	11.13	2.65	10.67	2.99	10.24	3.04	9.85
	0700	1.15	6.09	2.00	9.85	2.11	10.67	2.20	11.13
	1300	0.92	9.14	1.70	9.14	1.85	9.85	1.91	9.14
	1900	0.99	5.69	1.69	9.48	1.83	8.53	1.96	8.26
27	0100	0.94	6.92	1.60	9.48	1.78	7.31	1.84	10.67
	0700	1.17	8.53	2.12	9.48	2.29	8.53	2.48	8.53
	1300	0.81	9.14	2.52	9.14	2.46	9.48	3.05	9.14
	1900	1.14	10.67	2.63	10.24	3.01	10.24	3.27	10.24
28	0100	0.94	10.24	2.69	10.67	3.13	10.67	3.39	10.67
	0700	1.40	11.64	2.83	11.13	3.04	11.13	3.28	11.13
	1300	0.88	12.80	2.62	11.13	2.63	11.13	3.09	11.13
	1900	1.20	11.64	2.15	11.13	2.36	11.64	2.37	11.13
29	0100	0.69	11.64	1.61	11.64	1.86	11.13	1.73	11.64
	0700	1.07	11.64	1.37	11.13	1.66	11.13	1.92	11.13
	1300	0.60	11.13	1.25	10.67	1.48	10.67	1.51	10.67
	1900	0.87	11.13	1.11	10.67	1.41	11.13	1.55	11.13
30	0100	0.50	11.13	1.01	10.24	1.30	10.67	1.19	10.67
	0700	0.82	10.24	1.05	9.85	1.16	10.67	1.24	11.13
	1300	0.64	5.57	1.45	10.24	1.72	10.24	1.85	5.95
	1900	0.82	10.67	1.31	10.67	1.48	11.13	1.60	10.24
	Mean	0.56	7.60	1.03	8.30	1.09	8.31	1.22	7.99
	Std dev	0.33	3.30	0.62	2.39	0.70	2.22	0.74	2.24

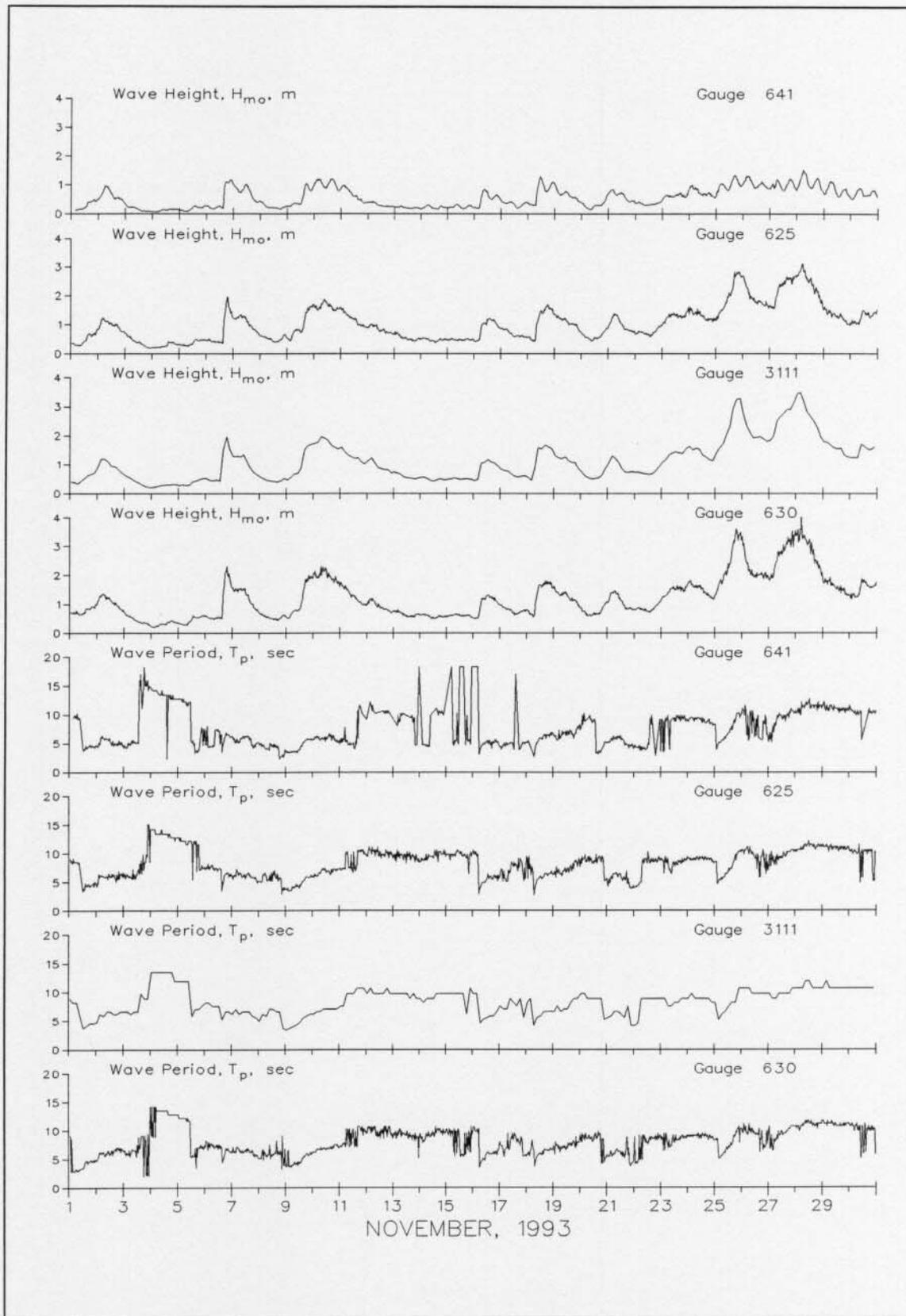


Figure 5. Time History of Wave Heights and Periods

4 Current Data

Current data (Table 5) are collected from a Marsh-McBirney electromagnetic biaxial current meter and by visually observing the movement of dye on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 6).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards.

Notice: The current meter data (gauges 519, 529, 3511, 3519) was fouled by marine growth from 16 NOV - 31 NOV. Please call us if you must use this data.

Table 5
Current Meter Data - Gauge 519

November 1993

Cross Long					Cross Long					Cross Long							
Day	Time	Shore	Shore	Speed	Dir	Day	Time	Shore	Shore	Speed	Dir	Day	Time	Shore	Shore	Speed	Dir
1	100	2	12	13	158	11	100	6	34	35	158	21	100	2	12	12	157
	700	0	-1	3	320		700	5	26	27	157		700	4	10	10	147
	1300	0	7	7	166		1300	0	9	9	170		1300	1	-1	2	10
	1900	0	0	0			1900	5	15	15	150		1900	1	-4	5	355
2	100	3	8	9	145	12	100	1	-1	3	14	22	100	0	-8	9	346
	700	2	4	5	140		700	0	-4	5	338		700	1	-7	8	354
	1300	4	12	12	148		1300	-2	-24	25	341		1300	0	-10	11	344
	1900	4	8	9	139		1900	-2	-15	16	338		1900	0	5	5	164
3	100	4	13	13	152	13	100	-3	-19	20	338	23	100	1	-2	3	359
	700	2	0	2	35		700	1	-5	6	354		700	2	6	6	150
	1300	6	7	9	129		1300	0	-3	4	353		1300	-5	0	6	272
	1900	1	2	2	143		1900	0	-3	4	351		1900	5	22	23	156
4	100	2	2	3	116	14	100	-1	-7	8	332	24	100	8	26	27	151
	700	0	-7	8	347		700	-1	-12	13	337		700	16	21	26	130
	1300	8	6	10	114		1300	-3	-10	11	330		1300	3	17	17	159
	1900	0	7	7	175		1900	-3	-9	11	328		1900	9	25	27	150
5	100	1	-5	6	356	15	100	-2	-16	18	338	25	100	2	23	23	163
	700	0	-18	19	344		700	-3	-20	22	336		700	5	33	34	160
	1300	-3	-12	13	332		1300	-4	-11	13	324		1300	5	38	38	161
	1900	-4	-17	18	334		1900	-2	-11	12	333		1900	16	62	64	153
6	100	-2	-10	12	332	16	100	0	-2	3	335	26	100	9	53	54	158
	700	-2	-14	16	338		700	2	4	5	142		700	7	39	40	158
	1300	0	-7	8	340		1300	6	26	26	155		1300	3	15	15	158
	1900	8	43	43	158		1900	3	22	22	159		1900	4	19	20	156
7	100	4	29	30	161	17	100	4	27	27	159	27	100	2	12	12	158
	700	3	19	20	158		700	1	15	15	163		700	6	-3	7	43
	1300	4	19	20	155		1300	3	19	19	158		1300	-1	8	8	183
	1900	4	18	18	155		1900	-2	10	10	185		1900	-1	-4	5	321
8	100	4	14	15	154	18	100	0	-1	2	318	28	100	1	-51	53	349
	700	3	11	12	152		700	0	-4	5	346		700	-4	-33	34	339
	1300	6	5	8	118		1300	7	38	39	158		1300	-9	-6	13	293
	1900	3	13	13	153		1900	6	35	36	158		1900	2	-4	6	8
9	100	9	16	19	138	19	100	6	25	26	156	29	100	0	6	6	182
	700	4	19	19	155		700	4	20	20	157		700	2	7	7	154
	1300	6	18	19	150		1300	6	23	23	154		1300	5	10	11	144
	1900	9	37	38	154		1900	5	16	17	151		1900	-2	4	5	207
10	100	7	37	37	158	20	100	0	12	12	170	30	100	0	6	6	171
	700	10	46	47	156		700	-2	-1	4	292		700	0	2	2	172
	1300	4	36	36	162		1300	0	3	3	161		1300	7	34	34	157
	1900	6	40	41	159		1900	2	8	8	154		1900	6	33	33	158

KEY:

+crossshore = offshore, cm/sec
 -crossshore = onshore, cm/sec
 +longshore = south, cm/sec
 -longshore = north, cm/sec
 Speed = Resultant speed, cm/sec
 Dir = Resultant direction, degrees true north

Table 6
Visually Observed Current Data

November 1993												
	Pier End				Mid-Surf Zone				Beach			
Day	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir	
1	19	15	24	109	8	10	13	123	South	8	S	
2	0	28	28	160	0	41	41	160	North	56	S	
3	2	-5	5	7	3	5	6	129	North	0		
4	10	10	14	70	0	5	5	160	North	0		
5	0	-29	29	340	0	-36	36	340	South	20	N	
6	0	-30	30	340	8	-15	17	7	South	8	N	
7	0	32	32	160	0	87	87	160	North	20	S	
8	0	29	29	160	0	24	24	160	North	21	S	
9	-4	14	14	177	0	27	27	160	North	26	S	
10	0	68	68	160	0	102	102	160	North	36	S	
11	0	32	32	160	0	44	44	160	North	6	S	
12	0	-3	3	340	0	-55	55	340	South	5	S	
13	7	-27	27	354	0	-47	47	340	South	21	N	
14	0	-24	24	340	0	-16	16	340	South	8	N	
15	11	-36	37	357	7	-22	23	357	South	25	N	
16	0	44	44	160	-42	55	69	197	North	81	S	
17	0	9	9	160	3	10	10	70	South	0		
18	0	55	55	160	0	87	87	160	North	152	S	
19	-20	34	39	191	-12	41	42	177	North	46	S	
20	19	13	23	104	20	-10	22	45	North	10	S	
21	-18	10	21	250	0	61	61	160	North	8	S	
22	-7	-12	14	309	0	-15	15	340	South	10	N	
23	-6	10	12	250	-30	-51	59	309	South	27	N	
24	0	0	0		-10	-102	102	334	South	25	N	
25	-10	51	52	171	0	76	76	160	North	18	S	
26	-7	24	25	177	-30	20	37	250	South	52	N	
27	-14	-15	21	298	0	-102	102	340	South	46	N	
28	0	-34	34	340	0	-152	152	340	South	51	N	
29	0	-23	23	340	0	-68	68	340	South	81	N	
30	0	34	34	160	0	32	32	160	North	76	S	

KEY:
 +crossshore = offshore, cm/sec
 -crossshore = onshore, cm/sec
 +longshore = south, cm/sec
 -longshore = north, cm/sec
 Speed = Resultant speed, cm/sec
 Dir = Resultant direction, degrees true north

5 Visual Observations

Visual wave direction measurements (Table 7) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The direction of the primary wave train just north of the seaward end of the pier is also determined using a Raytheon Marine Pathfinder radar and measuring the alignment of the wave crests at approximately the same location as the visual measurements. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

Table 7
Visual Observations

November 1993								
Day	Time	Wave Approach Angle at Pier End deg from True N		Radar Wave Angle deg from True N	Width of Surf Zone,m	Water Characteristics		
		Primary	Secondary			Temp.,C	Density g/cc	Secchi Vis.,m
1	0809	80	150	inoperative	3	16.4	1.0240	0.6
2	0710	40			84	15.6	1.0238	0.3
3	0800	60			3	15.8	1.0238	1.2
4	0730	65			3	14.7	1.0241	0.9
5	0700	80			3	15.8	1.0240	0.9
8	0815	90			3	16.7	1.0240	1.2
7	0820	110			280	15.3	1.0246	0.6
8	0720	80	40		18	14.7	1.0240	0.9
9	0715	45			52	14.7	1.0240	1.2
10	0730	45			110	13.9	1.0238	0.6
11	0725	60			99	12.8	1.0220	0.6
12	0715	95			17	13.9	1.0230	0.9
13	0815	90			52	14.2	1.0228	1.8
14	0645	40			3	15.8	1.0241	0.6
15	0705	85			6	15.8	1.0240	0.6
16	0725	40			5	15.6	1.0246	0.6
17	0705	50	80		38	15.8	1.0242	0.6
18	0917	35		30	49	15.8	1.0246	0.6
19	0715	40			73	15.0	1.0241	0.6
20	0815	80	40		3	14.7	1.0230	0.6
21	1005	40			81	14.2	1.0230	0.6
22	0555	95			3	13.9	1.0231	0.6
23	0715	95		80	94	14.2	1.0234	0.6
24	0840	90	40	85	114	14.4	1.0232	0.3
25	0900	45			408	13.6	1.0229	1.2
26	0850	70	55		251	12.8	1.0215	0.9
27	0835	95			125	13.3	1.0211	0.6
28	0920	90			189	15.0	1.0250	0.6
29	0720	85	20		88	13.9	1.0262	0.9
30	0850	55			58	13.6	1.0255	0.6

6 Water Levels

Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A Leupold-Stevens digital recording float-type tide gauge is used to collect instantaneous water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 6 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level. Table 8 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

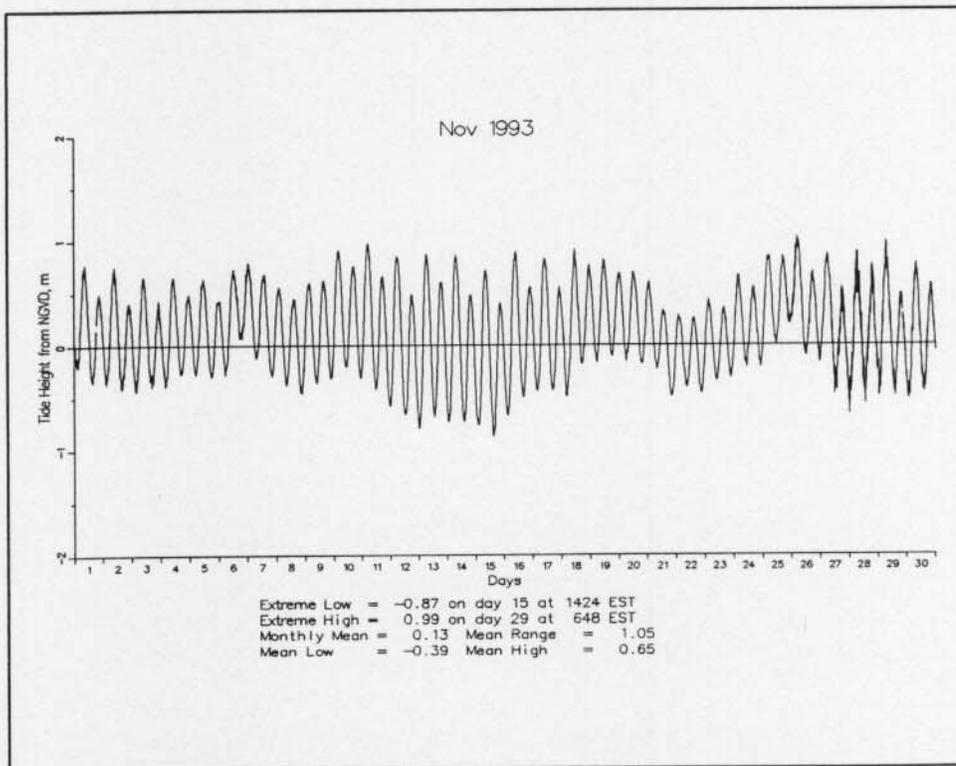


Figure 6. Water Level Time History

Table 8
Water Levels, m NGVD

November 93															
High			Low			Mean	Range	High			Low			Mean	Range
Day	Time	m	Day	Time	m			m	m	Day	Time	m	Day		
1	0800	0.78	1	0230	-0.21	0.25	0.98	16	0918	0.89	16	0218	-0.67	0.12	1.57
1	1954	0.50	1	1430	-0.35	0.06	0.85	16	2106	0.56	16	1530	-0.50	0.04	1.06
2	0900	0.76	2	0200	-0.37	0.19	1.12	17	0942	0.83	17	0306	-0.44	0.20	1.27
2	2054	0.41	2	1436	-0.41	-0.01	0.82	17	2200	0.56	17	1606	-0.43	0.05	0.99
3	0854	0.66	3	0312	-0.44	0.12	1.10	18	1048	0.91	18	0330	-0.49	0.19	1.41
3	2154	0.43	3	1612	-0.40	-0.03	0.83	18	2254	0.77	18	1612	-0.18	0.28	0.95
4	0930	0.65	4	0330	-0.39	0.15	1.04	19	1106	0.82	19	0518	-0.17	0.33	0.98
4	2254	0.49	4	1612	-0.27	0.09	0.76	19	2354	0.68	19	1818	-0.11	0.29	0.79
5	1048	0.64	5	0442	-0.28	0.19	0.92	20	1148	0.69	20	0554	-0.16	0.28	0.85
5	2348	0.43	5	1730	-0.30	0.07	0.73	21	0106	0.60	20	1842	-0.18	0.20	0.79
6	1206	0.73	6	0500	-0.28	0.29	1.01	21	1254	0.33	21	0736	-0.24	0.05	0.57
6	2354	0.79	7	0500	0.04	0.40	0.76	22	0142	0.29	21	1930	-0.49	-0.09	0.78
7	1348	0.68	7	0618	-0.12	0.26	0.80	22	1430	0.27	22	0836	-0.41	-0.07	0.68
8	0124	0.56	7	1942	-0.29	0.13	0.85	23	0236	0.44	22	2036	-0.47	-0.02	0.90
8	1400	0.45	8	0730	-0.38	0.04	0.83	23	1536	0.35	23	0918	-0.34	0.00	0.69
9	0312	0.60	8	2042	-0.46	0.09	1.05	24	0342	0.66	23	2100	-0.32	0.17	0.98
9	1454	0.62	9	0900	-0.37	0.14	0.99	24	1618	0.56	24	1024	-0.22	0.17	0.78
10	0336	0.91	9	2048	-0.32	0.31	1.22	25	0430	0.85	24	2148	-0.21	0.35	1.06
10	1630	0.76	10	1012	-0.21	0.27	0.97	25	1630	0.84	25	1100	0.02	0.42	0.83
11	0442	0.98	10	2218	-0.32	0.33	1.30	26	0436	1.03	25	2130	0.20	0.57	0.83
11	1654	0.66	11	1118	-0.43	0.11	1.08	26	1742	0.70	26	1148	-0.10	0.28	0.80
12	0506	0.85	11	2312	-0.58	0.15	1.43	27	0612	0.87	26	2312	-0.17	0.36	1.04
12	1736	0.49	12	1200	-0.66	-0.10	1.15	27	1748	0.55	27	1118	-0.48	0.02	1.02
13	0612	0.87	12	2330	-0.80	0.06	1.67	28	0606	0.89	27	2342	-0.66	0.13	1.56
13	1806	0.60	13	1248	-0.68	-0.03	1.28	28	1906	0.77	28	1300	-0.57	0.10	1.34
14	0700	0.87	14	0012	-0.73	0.08	1.60	29	0648	0.99	29	0024	-0.50	0.26	1.48
14	1936	0.48	14	1330	-0.73	-0.11	1.22	29	1842	0.49	29	1400	-0.49	0.00	0.98
15	0812	0.71	15	0124	-0.76	-0.03	1.47	30	0742	0.78	30	0142	-0.52	0.14	1.30
15	2018	0.41	15	1424	-0.87	-0.20	1.28	30	1930	0.58	30	1406	-0.45	0.07	1.04

7 Bathymetry

A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using the CRAB-Geodimeter surveying system; a Geodimeter 140-T self-tracking, electronic theodolite, distance meter, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 7 shows the last survey in October 1993 and the survey(s) in November 1993 on profile line 188, located 517 m south of the pier.

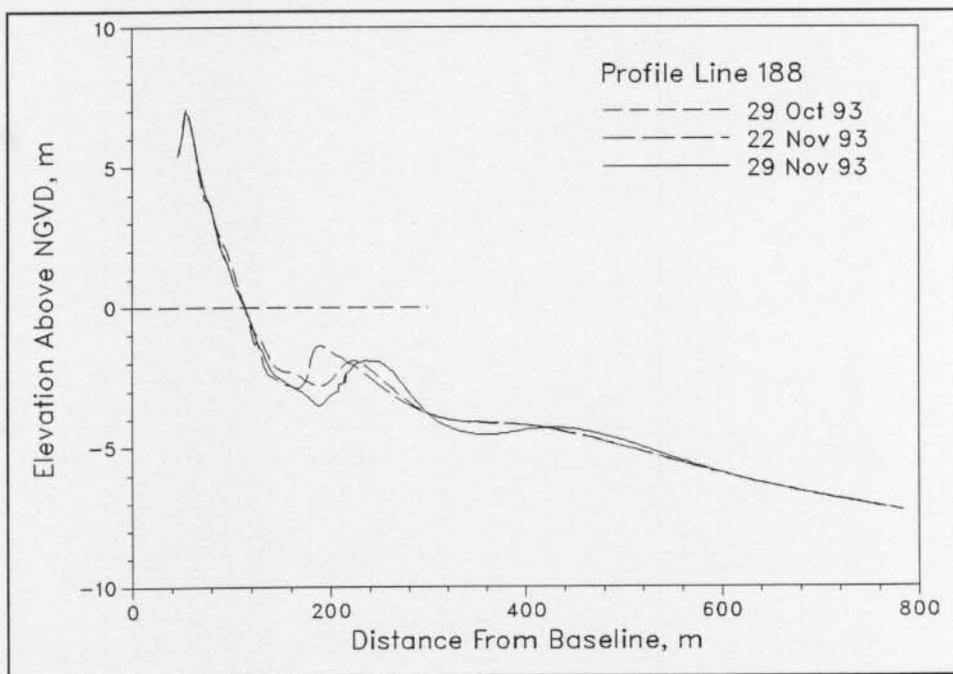


Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1993. Cross-hatched areas indicate changes to the annual envelope which occurred in November.

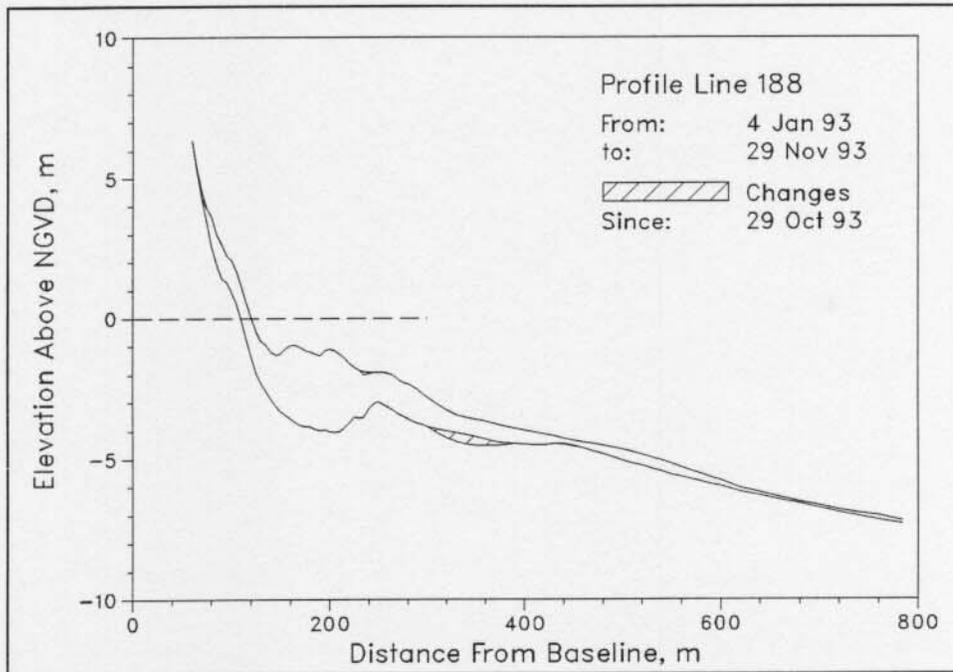


Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 22 November. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.

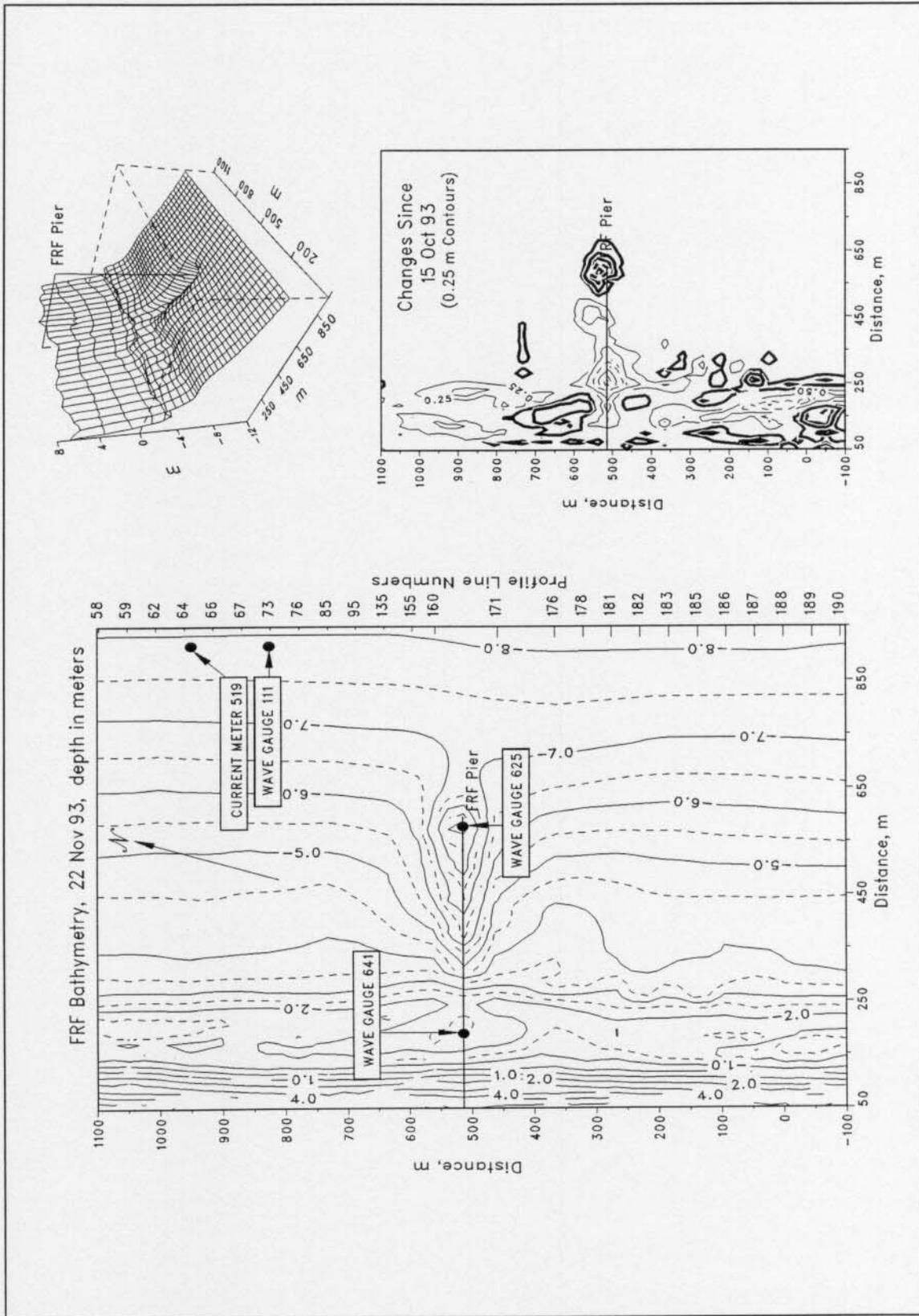


Figure 9. FRF Bathymetry, Depths Relative to NGVD

8 Special Events

A. Storm Data Collection. The following list identifies times when the wave height H_{mo} at the seaward end of the pier (i.e. as measured near the end of the pier) exceeded 2 m.

<u>Start</u>	<u>End</u>
25 Nov (1142)	28 Nov (2008)

B. Storm Synopsis.

Northeasterly winds were funneled between a high pressure system over Maine and a low pressure system over Florida. Winds intensified as the low pressure system moved northward along the coast. Maximum onshore winds reached 15 m/s at 2200 on 25 November. The maximum H_{mo} , at gauge 630, reached 4.12 m ($T_p = 10.7$ s) at 0508 on 28 November. There was 28 mm of precipitation.

Distribution List

Government Agencies:

Back Bay National Wildlife Refuge	U.S. Geological Survey
USACE-OCE	U.S. Library of Congress
USACE-SAD	U.S. National Park Service
USACE-NAP	U.S. National Weather Service
USACE-SAW	U.S. Naval Academy
USACE-WES	U.S. Naval Civil Eng. Lab
NAVSAC	U.S. Naval Oceanographic Off.
NOAA/NOS/OMS	U.S. Naval Research Lab
National Marine Fisheries	

Colleges/Universities:

Bucknell University	Scripps Institution of Oceanography
California Inst. of Tech.	Stockton State College
Duke Marine Lab	University Calif-Berkeley
East Carolina University	University of Florida
Florida Inst. of Tech.	University of Maryland-College Park
M.I.T.	University of Maryland-Baltimore
Naval Post Graduate School	University of North Carolina
NC State University	University of N C-Seagrant Program
Old Dominion University	University of Virginia
Oregon State University	Va. Inst. of Marine Science
Prince George's College	Rutgers University

Others:

Allied Signal Aerospace Co.	WCTI-TV
Applied Physics Lab	MEC Systems Corporation
Cape Hatteras Nat. Seashore	Moffatt & Nichol, Eng.
Coastal and Est. Res., Inc.	N.C. Div. Coastal Management
Coastal Science & Eng., Inc.	Oregon Inlet & Waterways Commis.
Dr. Cy Galvin	Raleigh-Durham Airport
GEOMET Tech., Inc.	Mr. Rowland
Mr. Hodges	Mr. Savage
Dr. Hylton	Science Application Int'l. Corp
Mr. Mason	Sherwood Industries
Mr. Rodgers	SEASUN Power Systems

Foreign:

Christchurch, Barbados
Ministry of Works, Bahamas
Dalhousie University, Halifax Nova Scotia
Queen's University, Ontario (Canada)
Ministry of Construction, Coastal Division (Japan)
Norwegian Hydrodynamic Laboratories (Norway)
University of Sydney (Australia)